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CHANGING DAIRY RATIONS AFFECTS--

- *digestibility*
- *rumen function*
- *feed intake*
- *milk production*

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CHANGING DAIRY RATIONS AFFECTS— Digestibility, Rumen Function, Feed Intake, and Milk Production

H. R. CONRAD, J. W. HIBBS, A. D. PRATT
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INTRODUCTION

Sudden changes in the type of roughage fed often result in serious reductions in daily milk production. This observation has been made in both experimental and farm herds. Under some conditions this has been associated with subclinical ketosis (12). The problem has been most acute when abrupt shifts have been made from corn silage and hay to forage crop silage. In recent years this problem has become more serious because of the increased use of forage crop silage. Furthermore, the fact that many dairymen are using both forage crop and corn silage during the course of a winter feeding season and that often both types of silage are stored in the same silo makes it difficult to avoid abrupt changes in the roughage.

Meadow crop silages are, by their very nature, highly variable in feeding value. They fluctuate from meadow to meadow because of differences in maturity of forage plants, kinds of plants, and the end products produced by the fermentation. Corn silage is a more uniform crop with respect to feeding value. Nevertheless meadow crop silage has proved to be a desirable roughage for dairy cows. Because of improved harvesting methods, it offers an efficient way to preserve the early forage crop in many areas where weather conditions are unfavorable for hay making.

In recent years several winter feeding trials conducted at the Ohio Agricultural Experiment Station have been directed at studying the problems of legume-grass silage utilization by dairy cows. The experiments to be reported here have shown that lowered digestibility after abrupt changes to legume-grass silage can account for the lowered milk yield in some trials but not in others. The results also have shown that as yet undetermined substances in legume-grass silage may also be responsible in part for the reduced milk production after initiation of silage feeding.

EXPERIMENTAL PROCEDURES AND RESULTS

Records of milk production and feed intake were kept on 74 cows during four winter feeding experiments (1954-1957), 90 digestion and nitrogen balance trials were carried out, and in 2 experiments, studies of rumen digestion were made.

Dry matter determinations were made on all dry feed periodically and feces samples by oven drying 24 to 48 hr. at 100° C. The majority of silage dry matter determinations were made by toluene distillation. Nitrogen determinations were made by the Kjeldahl procedure.

Volatile fatty acids (VFA) in rumen contents were determined by partitioning into acetic, propionic and butyric (plus higher) acid fractions using modification of the method of Bulen **et al.** (**2**) described by Linke (**8**).

VFA production and protein synthesis in vitro were determined using 8 ml. of strained rumen juice as the inoculum in 18-hr. fermentations. Substrates for these in vitro fermentations were 8 ml. of silage juice, 1 g. of corn and cob meal reduced to 30 percent grain, and 5 ml. of mineral buffer described by Bentley **et al.** (**1**).

Wet smears and Gram stains of rumen contents or cud material obtained from experimental cows were used for rating rumen microorganisms using the indicator method of Pounden and Hibbs (**13**).

Digestion and nitrogen balance determinations were carried out using the cows that were included in feeding trials. They were kept in the stalls which they normally occupied. Separate collection of feces and urine was made using modifications of the procedure outlined by Hansard **et al.** (**5**). Three-in. Gooch tubing was attached to each cow covering the opening of the vulva. Branding cement and "Neomat" straps for supporting attachments were used to affix the tubing to the cows. Urine was accumulated in large rubber bags for approximately 12-hr. periods. The cows stood on rubber mats in place of straw-bedding. The feces were collected on Sisalkraft paper four feet in width. Only apparent protein digestibility was determined. Further references to protein digestibility refer to apparent digestibility.

Differences in milk production were tested statistically by the analysis of covariance and differences in feed intake by analysis of variance (**15**).

EXPERIMENT 1

EFFECT OF CHANGING FROM CORN SILAGE TO LEGUME-GRASS SILAGE AND HAY

The observations presented in this experiment were made in conjunction with a series of four winter feeding trials carried out to study the effects of various ratios of hay to silage and roughage to grain on milk production. The ratio studies will be reported elsewhere.

Daily milk production, recorded routinely, was summarized for four different groups of cows with calving dates ranging from July through October. Group 1 consisted of 12 Jersey and 3 Holstein cows (in 1954), group 2 consisted of 12 Jerseys and 6 Holstein cows (in 1955), group 3 consisted of 4 Jersey and 6 Holstein cows (in 1956), group 4 consisted of 4 Jersey and 8 Holstein cows (in 1957). The period of study covered 4 wk. before and 4 wk. after changing silages.

During the first 4-wk. period no roughage consumption records were kept and the role of grain cannot be safely evaluated in these observations. Grain was fed at the rate of 1 lb. per 4 lb. of milk for Jerseys and 1 lb. per 5 lb. of milk for Holsteins with a maximum of 12 lb. for both breeds.

In the second 4-wk. period, after grass-legume silage feeding was begun, daily feeding records were kept and grain was fed in proportion to the roughage consumed, in the ratio of 3 parts roughage and 1 part grain on the dry basis. The only exception being that both 2:1 and 3:1 ratios were fed to cows in group 4. The first three groups used in this experiment were fed corn silage and first cutting alfalfa-grass or other types of mixed hay after the pasture season, and then changed abruptly to legume-grass silage and hay fed in equal amounts on the dry basis. The cows in group 4 were adjusted to legume-grass silage by feeding it in equal amounts with a mixed hay starting 2-4 weeks before their calving dates. These cows were then changed to legume-grass silage as the only roughage.

Digestibility of dry matter and total nitrogen and nitrogen balance were determined using 5- or 7-day collection periods at various intervals during the legume-grass silage feeding periods. During these experiments microbiological ratings were made on cud material obtained from eight cows (group 1) which were fed corn silage and hay and 10 cows (group 4) fed legume-grass silage as the only roughage.

The results are summarized (Table 1). Decreases in milk production ranged from 7.8 to 21.5 percent when the cows in groups 1, 2, and 3 were shifted abruptly from corn silage to legume-grass silage.

TABLE 1.—Digestibility, feed intake, nitrogen retention and milk production of cows fed legume-grass silage and hay in equal proportions after shifting abruptly from corn silage and hay as compared to cows fed legume-grass silage after 6 to 8 weeks adjustment period on legume-grass silage and hay.

	Groups	
	1 (1954)	2 (1955)
Roughage, 1st 4-wk. period	Corn Silage + Hay	Corn Sil., Pasture + Hay
Roughage, 2nd 4-wk. period	Legume-grass Sil. + Hay	Legume-grass Sil. + Hay
Adjustment period, (wk.)	None	None
Number of animals	15	18
Dry matter intake, (lb./d.)		
1. Jerseys	19.7	19.8
2. Holsteins	31.4	31.1
Dry matter digested, (%)	66.5	65.4
Protein digested, (%)	63.0	68.2
Nitrogen balance, (g./d.)	+3.0	+2.4
Milk, 1st 4-wk. period, (av. lb./d.)	35.6	38.3
Milk, 2nd 4-wk. period, (av. lb./d.)	28.6*	35.3*
Decrease in milk, (%)	19.6	7.8

	Groups	
	3 (1956)	4 (1957)
Roughage, 1st 4-wk. period	Corn Silage + Hay	Legume-grass Sil. + Hay
Roughage, 2nd 4-wk. period	Legume-grass Sil. + Hay	Legume-grass Silage
Adjustment period, (wk.)	None	6-8 wk.
Number of animals	10	12
Dry matter intake, (lb./d.)		
1. Jerseys	21.2	22.5
2. Holsteins	29.9	27.7
Dry matter digested, (%)	63.0	65.6
Protein digested, (%)	63.8	72.0
Nitrogen balance, (g./d.)	+39.7	+30.7
Milk, 1st 4-wk. period, (av. lb./d.)	38.7	33.5
Milk, 2nd 4-wk. period, (av. lb./d.)	30.4*	33.5
Decrease in milk, (%)	21.5	0.0

*$P < .01$, significantly under expected production based on 1st 4 wk. period.

The abruptness of this decrease is shown (Figure 1). The cows in group 4, which were adjusted to legume-grass silage by starting silage feeding with hay 2 to 4 wk. before calving, on the other hand, produced the same amount of milk after changing to legume-grass silage as the only roughage.

The lactation curve of their average milk production is relatively level. That the differences might be associated with rumen function was indicated by the rumen bacterial picture, Table 2. It will be noted that most of the Hay II bacteria were absent from the rumen contents of cows fed legume-grass silage as the only roughage. Other data, Table 1, show that dry matter intake and digestibility were approximately the same for the cows fed silage with hay made from the same legume-grass forage as for the cows fed legume-grass forage only.

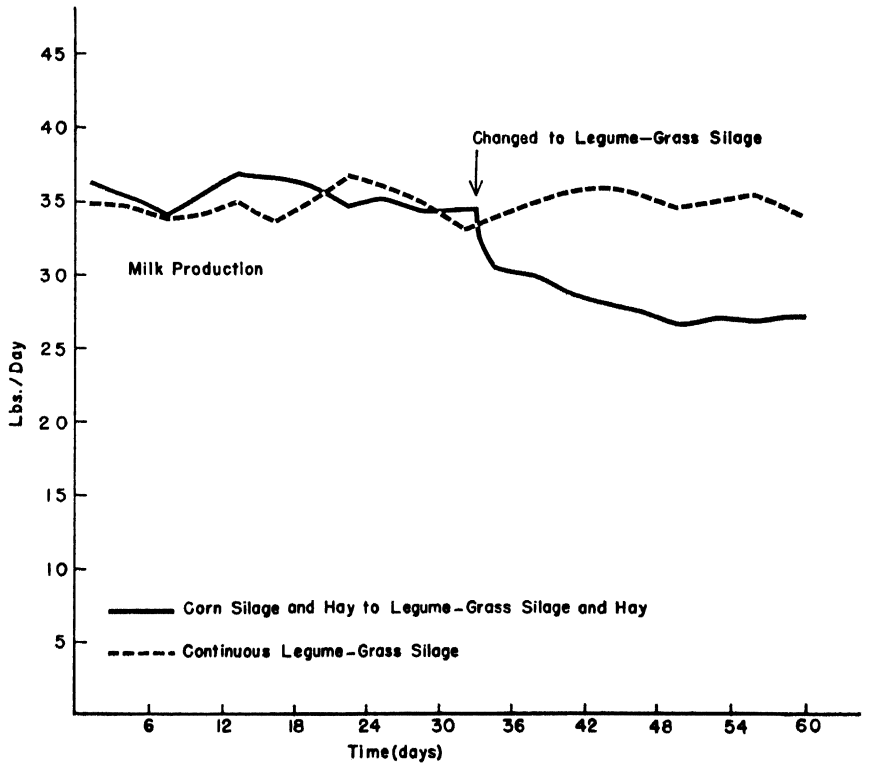

Fig. 1.—Milk production before and after changing cows abruptly from corn silage and hay to legume-grass silage and hay compared with continuous legume-grass silage feeding.

TABLE 2.—The comparative ratings of rumen microorganisms in cows fed limited amounts of corn silage and hay or legume-grass silage.

Rumen Microorganisms*	Corn silage and hay	Legume-grass silage
Number of cows	8	10
Protozoa	3 2	3 5
Hay I		
a Large G+ coccoids	2 2	2 9
Hay II		
a Large G+ square ended rods	0 7	0 0
b Very large G—, cigar shaped rods	0 5	0 0
c G— short rods in groups of four and its multiples	1 7	0 7

*Each microorganism rated 0-4

Sufficient feed records were not available to evaluate the role of grain and changes in digestible nutrient intake on the decline in milk production.

EXPERIMENT 2

EFFECT OF CHANGING THE ROUGHAGE FROM CORN SILAGE AND ALFALFA HAY TO ALL LEGUME-GRASS SILAGE OR CORN-PRESERVED LEGUME-GRASS SILAGE

Four cows, two Jerseys and two Holsteins, in the early stage of lactation were used to study the effect of changing from corn silage and hay to legume-grass silage as the only roughage on feed intake and milk production. At the beginning of the trial these cows had been receiving corn silage and mixed alfalfa-grass hay for a period exceeding 2 months time. They were changed to free choice legume-grass silage entirely during a 10-day change-over period. The amount of grain, which was being fed at the rates of 6, 9, 10, and 12 lb. daily to 4 different cows, was held constant after legume-grass silage feeding was started. Daily feed intakes and milk production were measured for a 6-week period. Feed dry matter was determined at various intervals and daily dry matter consumption calculated. Seven-day digestion and nitrogen balance trials were carried out during the 2nd, 4th and 6th week.

The average daily silage dry matter consumption is shown, (Figure 2). Dry silage intake rose 3 lb. during the first 21 days and then leveled out at approximately 14.5 lb. when legume-grass silage was

fed after corn silage and hay feeding period. Milk production declined sharply after the change-over, Table 3. Furthermore, protein digestibility increased from 64.8 during the 2nd wk. of legume-grass silage feeding to 70.8 and 71.8 percent respectively during the 4th and 6th week, Table 3. Dry matter digestibility was constant but relatively low.

In a second trial, four Jersey cows in the latter stages of their lactation were placed on corn silage and alfalfa hay for a 2 wk. period after the pasture season. They were then changed abruptly to corn-preserved (150 lb. of corn and cob meal per ton), wilted legume-grass silage for a

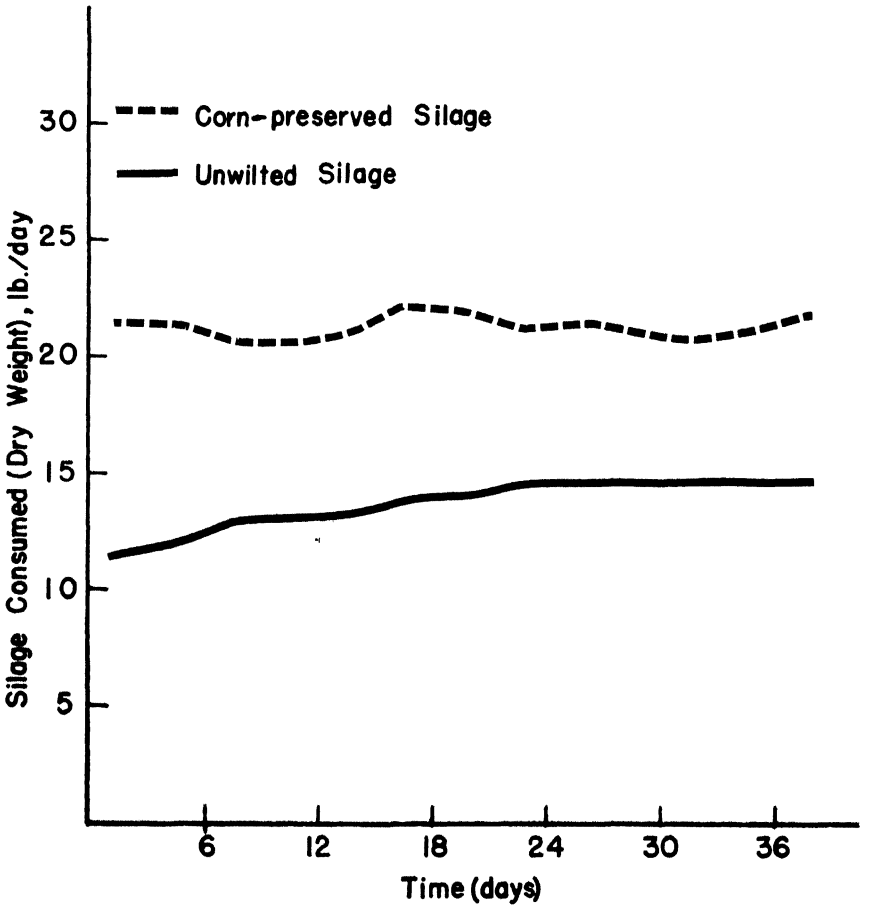

Fig. 2.—Silage dry matter consumed after initiation of unwilted legume-grass or corn-preserved legume-grass silage feeding.

6-wk. period. Daily feed intake and milk production were measured while each type of silage was fed. Five-day digestion and nitrogen balances were carried out during the 2nd week of the corn silage feeding period and the 1st, 3rd and 6th week of the corn preserved grass-legume silage feeding period. Smears were made of rumen contents obtained by stomach tube during each silage feeding period and were rated for

TABLE 3.—Feed intake, digestibility, nitrogen retention and daily milk production cows shifted abruptly from corn silage and alfalfa hay to either legume-grass or corn-preserved legume-grass silage.

	Trial 1 (4 cows) Corn Silage to Legume-grass Silage				
	Dry Matter Intake	Dry Matter Digested	Protein Digested	Milk	Nitrogen Balance
	(lb.)	(%)	(%)	(lb.)	(g./d.)
Corn silage—Preliminary	----	----	----	37.5*	----
Legume-grass silage					
1st week	19.4†	----	----	32.5	----
2nd week	20.9	60.5	64.8	30.7	—12.8
3rd week	22.0	----	----	29.2	----
4th week	22.3	59.8	70.8	29.9	+21.6
5th week	22.4	----	----	30.0	----
6th week	21.6	60.9	71.8	30.3	+16 8

	Trial 2 (4 cows) Corn Silage and Hay to Corn Preserved Legume-grass Silage				
	Dry Matter Intake	Dry Matter Digested	Protein Digested	Milk	Nitrogen Balance
	(lb.)	(%)	(%)	(lb.)	(g./d.)
Corn silage—Preliminary	24.5	65.8	56.1	17.4	—20.7
Legume-grass silage					
1st week	25.6	62.7	68.2	17.1	+22.5
2nd week	25.9	----	----	17.9	----
3rd week	27.3	64.8	66.0	17.8	+21.8
4th week	26.5	----	----	18.1	----
5th week	26.5	----	----	17.9	----
6th week	26.2	62.0	66.4	17.3	+34.2

* $P<.01$, significantly over legume-grass silage.

† $P<.01$, significantly under 3rd, 4th and 5th week.

rumen protozoa and bacteria using the indicator method. Strained rumen juice from each cow was used as inoculum to determine the rate of protein synthesis in vitro.

In contrast to the group of cows in Trial 1, silage dry matter intake was higher and essentially constant with time after changing to corn-preserved legume-grass silage. No significant differences were observed in dry matter digestibility. Compared to values for corn silage and hay feeding, the dry matter intake and digestibility were increased on corn-preserved grass-legume silage.

The data showing average protein synthesis in vitro, Table 4, indicate that ruminal synthesis may have been limited during the corn silage feeding period and during the period directly after changing abruptly to corn-preserved legume-grass silage. It will be noted that the highest value for protein synthesis occurred with inoculum obtained 17 days after the change-over. In both trial I and trial II of this experiment increased ruminal protein synthesis with time after the change-over to grass-legume silage may have contributed to the improvement in the nitrogen nutrition as indicated by a greater positive nitrogen balance when milk yield remained essentially constant, Table 3.

TABLE 4.—Effect of abruptly changing from corn silage to corn-preserved legume-grass silage on in vitro protein synthesis using rumen contents from 4 cows as inoculum.

Digestion Period	Kind of Silage	Time on Roughage	In Vitro Protein Synthesis*
		(d.)	(mg./hr./l.)
1	corn silage	7	46.3
2	corn-preserved legume-grass	3	72.5
3	corn-preserved legume-grass	17	226.3
4	corn-preserved legume-grass	38	205.0

*Eighteen hour fermentations. Protein synthesis was calculated per liter of rumen juice.

EXPERIMENT 3

CORN SILAGE AND HAY VERSUS LEGUME-GRASS SILAGE AND HAY: EFFECT ON MILK PRODUCTION, FEED INTAKE, DIGESTIBILITY AND RUMEN SYNTHESIS

This experiment differs from preceding experiments in that more detailed measurements were made. To help eliminate the possible effects of ration changes on rumen function indicated in the results of the two previous experiments, one-third of the dry roughage in both the corn and legume-grass silage feeding periods was supplied by alfalfa hay containing 10 to 20 percent grass, and the total protein content of the grain mixture fed was kept at 16 percent throughout the experiment. It was anticipated that the continued hay feeding would help maintain a more-balanced rumen microflora and that a relatively high protein level in the grain mix would compensate for possible lowered protein synthesis after changing over from corn silage.

Seven cows, four Jerseys, two Guernseys and one Holstein, were allowed to consume corn silage and alfalfa hay free choice, on the dry basis of a 2:1 ratio, for a period of 7 weeks. The corn silage was then

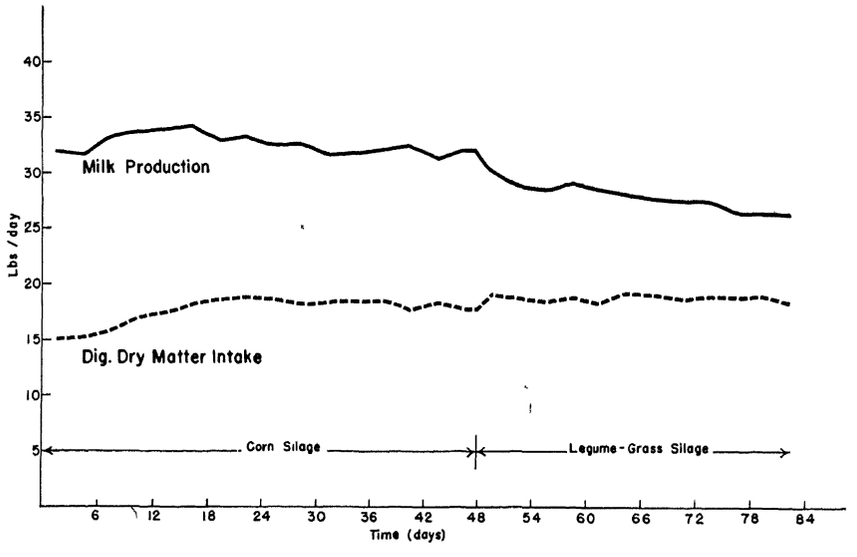

Fig. 3.—Changes in milk production and digestible dry matter intake before and after shifting abruptly from corn silage and hay to legume-grass silage and hay.

replaced abruptly with legume-grass silage and the 2:1 ratio of silage to hay was continued for an additional 5-week period. Daily feed intake and milk production records were kept. Digestibility and nitrogen balances were determined at 2-wk. intervals during the 2nd, 4th and 6th week of the corn silage feeding period and during the 1st, 3rd and

TABLE 5.—The effects of changing abruptly from corn silage to legume-grass silage on the digestion and nitrogen utilization by dairy cows fed grass-legume silage (4 cows).

	Corn Silage		
	Trial 1	**Trial 2**	**Trial 3**
Time on silage, (**d.**)	8	22	36
Roughage:Grain Ratio	48:52	50:50	49:51
Dry matter digested, (**%**)	66.8	68.8	68.3
Dry matter intake, (**lb./d.**)	22.5	23.4	23.5
Protein digested, (**%**)	66.7	69.2	63.4
Protein synthesis in vitro, (**mg./hr./l.**)	260.9	148.8	179.6
Milk, (**lb./d.**)	27.8	26.0	25.8
Nitrogen balance, (**g./d.**)	8.7	41.6	0.3
Efficiency for milk nitrogen, (**%**)*	46.7	36.3	48.1
Total nitrogen efficiency, (**%**)†	35.3	42.2	30.7
ENE intake, (**therms**)‡	15.5	16.2	16.1

	Grass-legume Silage		
	Trial 4	**Trial 5**	**Trial 6**
Time on silage, (**d.**)	3	17	31
Roughage:Grain Ratio	68:32	68:32	68:32
Dry matter digested, (**%**)	71.0	69.4	69.5
Dry matter intake, (**lb./d.**)	24.1	24.0	23.8
Protein digested, (**%**)	71.2	71.4	72.9
Protein synthesis in vitro, (**mg./hr./l.**)	239.6	----	237.2
Milk, (**lb./d.**)	22.8§	22.0§	21.3§
Nitrogen balance, (**g./d.**)	30.4	23.7	32.9
Efficiency for milk nitrogen, (**%**)*	31.8	30.3	28.8
Total nitrogen efficiency, (**%**)†	35.1	32.4	33.8
ENE intake, (**therms**)‡	15.5	15.9	15.8

*Milk nitrogen divided by nitrogen absorbed.

†Milk nitrogen plus stored nitrogen divided by total nitrogen intake.

‡Calculated—based on Morrison's Table II. (**10**).

§$P < .01$, significant under trials 1, 2, and 3.

5th week of the legume-grass silage feeding period, using 5-day collection periods. Rumen samples were also obtained for the purpose of determining rumen VFA, VFA production, protein synthesis in vitro, and ratings for indicator rumen microorganisms.

Average daily milk production and digestible dry matter are shown (Figure 3). As in the previous experiments milk production dropped approximately 17 percent while digestible dry matter rose slightly after the change-over to grass-legume silage. This rules out the possibility that a decrease in digestible nutrient intake caused the drop in milk production. The other data from this experiment, Tables 5 and 6, indicate also that protein digestibility, ruminal protein synthesis, changes in types of rumen microorganisms, or amount of volatile fatty acids produced were not involved.

TABLE 6.—The effect of changing abruptly from corn silage to legume-grass silage on the rating of rumen microorganisms, volatile fatty acids in the rumen contents, and in vitro synthesis volatile fatty acids.

	Corn Silage	Grass-legume Silage
Rumen microorganisms:*		
Protozoa	2.6	2.0
Hay I		
a. Large G+ coccoids	3.1	2.0
Hay II		
a. Large G+, square-ended rods	0.9	1.4
b. Very large G—, cigar shaped rods	0.9	0.8
c. G— short rods in groups of four and its multiples	2.0	1.8
Rumen VFA†		
Acetic, (g./l.)	3.39 ± 1.25	3.65 ± 0.66
Propionic, (g./l.)	1.08 ± 0.41	1.13 ± 0.75
Butyric, (g./l.)	1.00 ± 0.47	0.92 ± 0.20
In vitro VFA:†		
Acetic, (meq./hr.)	14.48 ± 4.30	16.28 ± 8.46
Propionic, (meq./hr.)	9.16 ± 1.76	10.42 ± 3.52
Butyric, (meq./hr.)	4.28 ± 1.97	6.21 ± 4.18

*Each microorganism rated 0-4.

†± Values are standard deviations.

It is of interest that the proportion of roughage to grain in the total ration shifted from approximately 50:50 during the corn silage feeding period to 68:32 when legume-grass silage was fed, Table 5. The overall efficiency of nitrogen utilization remained the same, but the average nitrogen balance increased with the decreased milk production when grass-legume silage was fed, Table 5.

EXPERIMENT 4

EFFECT OF CHANGING THE ROUGHAGE RATION FROM WILTED LEGUME-GRASS SILAGE TO CORN-PRESERVED LEGUME-GRASS SILAGE AND THEN TO ALFALFA HAY

Four cows were fed a wilted legume-grass silage as the only roughage for an 8-week period and then shifted abruptly to a corn-preserved (200 lb. of corn and cob meal per ton), wilted legume-grass silage which had been harvested from the same meadows for an additional 8-wk. feeding period. At the end of the latter feeding period the cows were shifted abruptly to alfalfa hay as the only roughage for the final 6-week feeding period. Roughage and grain were fed in a 2:1 ratio to two cows and a 3:1 ratio to the two remaining animals.

These ratios represent approximations only since the amount of grain eaten in the corn-preserved silage was calculated on the basis of the percentage added to green material and daily variations in dry matter prevent precise regulation of the hay:grain ratio at the time of feeding. However, weekly dry matter determinations were made on the forage being fed and the percent of grain in the silage calculated. From these data the forage to grain ratio was calculated at the time of each digestion trial, Table 7. Digestion trials were conducted during the 6th week of period 1, 4th and 8th week of period 2 and the 1st and 6th week of period 3. Urine and feces were collected separately and nitrogen balance determined. Records of daily milk production were kept.

The data presented in Table 7, show that milk production and dry matter intake decreased as the dry matter digestibility dropped 6.8 percentage units to 56.4 percent after abruptly changing the ration from wilted legume-grass to corn-preserved legume-grass silage ensiled from the same forage crop. After 51 days on the corn-preserved legume-grass silage, digestibility rose to 60.2 percent. Apparent protein digestibility was affected less. Part of the difference between the two types of silage may have been caused by he slightly higher proportion of grain fed in the total ration of the first trials, 29.5 percent, compared to 27.2

TABLE 7.—Digestibility, feed intake, nitrogen retention and milk production of cows fed legume-grass silage, wilted or preserved with corn and cob meal compared to cows fed alfalfa hay in similar hay grain ratios.

	Legume-grass Silage				
	Wilted	Corn Preserved		Alfalfa Hay	
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Number of cows*	4	4	4	4	4
Days on roughage, (d.)	33	21	51	4	39
Dry matter intake, (lb./d.)	25.6	19.4‡	20.5‡	29.3§	32.0§
Amount of roughage, (%)†	70.5	72.8	73.1	72.3	73.3
Dry matter digested, (%)	63.2	56.4‡	60.2	70.4§	69.5§
Protein digested, (%)	66.8	62.6‡	66.7	72.1	63.1
Nitrogen balance, (g./d.)	8.8	16.7	20.1	95.3	16.7
Milk produced, (lb./d.)	25.1	20.6‡	19.6‡	20.5	21.4

*Values for 2 Jerseys and 2 Guernseys on a 2:1 ratio and two cows on a 3:1 ratio summed and averaged.

†Percent of total dry matter.

‡$P<.01$, significant under trial 1.

§$P<.01$, significant over trial 1.

percent and 26.9 percent for trials 2 and 3. This is not sufficient however to account for the marked decrease in digestibility observed in trial 2.

The cows were apparently limited by serious deficiencies in digestibility of the ration as both dry matter digestibility and intake rose to relatively high levels within 4 days after changing to alfalfa hay and grain fed in either a 3:1 or a 2:1 ratio. Although most of the cows were in the 6th and 7th month of lactation, milk production began increasing and leveled off after 2 weeks.

DISCUSSION

The fact that milk production decreased following initiation of legume-grass silage feeding in experiment 3 while feed intake and digested dry matter were increasing suggests that criteria other than digestibility are needed to elucidate some unrecognized factor(s) in legume-grass silage which depress milk production. Although digestibility was maintained at a higher level, when the grain content of corn

silage was estimated, the proportion of grain in the total ration was calculated to have been lowered from approximately 50 percent to 32 percent by shifting to legume-grass silage. Since net energy determinations were not made, the possibility that the results were caused by a higher net energy value for corn silage cannot be excluded.

The higher level of nitrogen retained over and above the nitrogen used for milk protein when legume silage was fed, Table 5, suggests that net energy was not restricted in this experiment. Also estimated net energy intakes that were calculated were approximately the same, Table 5. Furthermore, it will be noted that the rumen VFA data, Table 6, showed no major changes in type of energy fermentation as indicated by the quantity and proportion of acetic, propionic and butyric acids found.

These differences in lacation response may be likened to the results obtained by Huffman and Duncan (**6**), although the feeding regimen is quite different. In their experiments alfalfa hay was fed until live weight and milk production changes became minimal and then a portion of the alfalfa was replaced with an equivalent amount of total digestible nutrients from corn silage. Insertion of corn silage on TDN equivalent basis increased milk production. Others (**7, 9, 14**) have accounted for most, but not all (**16**), of this increase on the basis of increased net energy intake. More recently Teichman **et al.** (**16**), using cows depleted with rations composed of 80 percent alfalfa and 20 percent grain, did not show further lactation response when additional corn was substituted on the TDN basis. Because of the relatively high level of grain used and the increase in nitrogen storage it does not appear that the net-energy-decrease concept would have application in our experiments.

The nitrogen utilization data obtained in experiment 3 is of interest also. Despite a decrease in the utilization of nitrogen for milk production, the nitrogen balances show that overall nitrogen retention was higher in the cows fed legume-grass silage. Consequently total nitrogen efficiency was approximately the same with both types of silages fed. This shift in nitrogen utilization suggests a direct effect on intermediate protein metabolism or a shift in the absorbed metabolites available.

When the milk production and digestibility data were considered along with the marked, immediate break in the lactation curves, Figures 1 and 3, it was concluded that under certain conditions there is some substance in legume-grass silage that causes a reduction in milk yield, notably when changing abruptly from corn silage to legume-grass silage. Preliminary iodine uptake studies have indicated involvement of the thyroid (**17**).

That digestibility differences may cause a major part of the decline in milk production when cows are shifted abruptly to legume-grass silage is indicated by the results in experiments 2 and 4. For example, in experiment 2, the dry matter digestibility was low (approximately 60 percent, Table 3) and the cows required 3 to 4 wk. to reach maximum daily silage intake after changing from corn silage and hay to legume-grass silage (Figure 2). Whereas, when dry matter digestibility rose in trial 2, Table 3, after changing from corn silage to corn-preserved legume-grass silage, feed intake increased and milk production tended to increase. It is interesting that high digestibility and increased feed intake were obtained on the one hand with cows shifted abruptly from corn silage to corn-preserved legume-grass silage whereas depressed digestibility and lowered feed intake was obtained when the abrupt shift was made from legume-grass silage to corn-preserved legume-grass silage, Table 7. In the latter experiment digestibility had recovered somewhat after a 2-week feeding period on corn-preserved legume-grass silage.

The data obtained (Tables 3, 4, 5 and 7) on apparent protein digestibility and in vitro protein synthesis with rumen contents indicated that ruminal protein synthesis may be limited immediately after an abrupt shift from corn silage to legume-grass silage, but the duration of the period of time involved is indicated to be less than 3 weeks.

It is concluded from the results of these experiments that sudden changes in type of roughage and the resultant changes in the proportion of grain fed affected the digestibility of the forage causing a reduction in milk production.

The procedure of adapting cows to legume-grass silage rations 2-4 wk. before calving, used for group 4 of experiment 1, permitted satisfactory milk production. This procedure merits consideration when milk cows are to be fed legume-grass silages. The data presented (Table 2) establishes that a high proportion of legume-grass silage in the ration has a marked influence on the rumen microflora. Based on the results in Table 4 and other results (**3, 4, 11**), it seems reasonable to assume that adjustments in synthetic and digestive processes will have been reduced to a minimum in 2 to 4 weeks time after an abrupt change.

The results of these experiments show the useful role of digestion and balance trials in lactation studies. Using the Gooch-tubing-technique for separate collection of urine and feces (**5**), the digestibility and balance studies are easily accomplished in the usual, individual-type stanchions employed in most stanchion-type barns, provided electric

stall trainers have been installed. Under these conditions collection periods up to 10 days in length may be carried out without significant effects on feed intake or milk production.

APPLICATION OF RESULTS

These experiments have shown that lowered digestibility can account for the lowered milk production in some cases but not in others. The experiments also show that undetermined substances in legume-grass silage may be responsible for the reduced milk production. On the other hand high levels of milk production were maintained in cows which were adapted to legume-grass silage feeding before freshening.

Ration changes initiated during lactation have showed that milk production dropped 10 to 20 percent and then recovered somewhat when cows were shifted abruptly to forage-crop silage from either pasture or corn silage and hay.

In these experiments forage-crop silage was utilized best when feeding was initiated 3 to 6 wk. before freshening and continued through the early months of lactation. Figure 1 illustrates the effect on milk production caused by changing suddenly from corn silage and hay to legume-grass silage and hay.

It was found also that digestibility decreased and then gradually rose to the expected level during a period of 3 to 4 weeks after starting forage-crop silage feeding. This lowered digestibility was accompanied by less than maximum roughage intake. It required 4 to 6 weeks before some cows reached their highest daily silage intake. Thus reduced milk yields were caused partly by reduced feed intake as well as lowered digestibility.

When cows are changed abruptly from corn silage to grass silage without an increase in grain to compensate for that lost in the corn, they experience a reduction in energy intake and a change in the bacterial population of the rumen. While the rumen bacteria adjust to the change, digestibility of the feed is reduced. Reversing the shift in silage (forage crop to corn) may also affect digestion adversely because of rumen bacterial adjustment.

Also, when corn-preserved legume-grass (150 lb. of corn and cob meal per ton) was fed following wilted legume-grass silage, digestibility of the roughage intake decreased and so did milk production.

Other important factors affecting milk production have been implicated in abrupt changes of the roughage ration. For example when rations were fed which eliminated digestibility differences milk production was still reduced 12 percent when cows were shifted from corn silage and hay to forage-crop silage and hay.

Thus, in order to help prevent drops in milk production and yet use maximum amounts of forage-crop silage, sudden changes in ration should be avoided whenever possible. The following feeding-suggestions are offered:

1. Adapt the cows to forage-crop silage during the month before freshening.

2. Make changes in the amount of supplemental grain fed to compensate for the grain in corn silage when changing to forage-crop silage.

3. If possible avoid refilling silos containing grass-legume silage with corn silage. If this is necessary use corn and cob meal to preserve the forage-crop silage (150 pounds per ton).

4. Use early-cut forage for silage-making.

5. The digestible protein content of the total ration should be maintained at 8 percent or higher when large amounts of forage-crop silage are being fed.

6. Certain systems of roughage feeding tend to complement each other and thus reduce the effects of sudden roughage changes. The following suggested systems of changing roughages will help avoid some of the more drastic effects of sudden ration changes.

   a. Green chop or pasture to hay.
   b. Legume-grass silage with or without hay throughout the year.
   c. Pasture followed by gradual change to legume-grass silage and hay.
   d. Pasture or green chop to corn silage and alfalfa hay.
   e. Pasture to corn silage to corn-preserved legume-grass silage.

SUMMARY

Records of milk production and feed intake were kept on 74 lactating cows fed in eight groups during four experiments in which the type of roughage fed was changed abruptly. Ninety digestion and nitrogen balance trials were carried out along with a limited number of studies on changes in the rumen microflora and **in vitro** protein synthesis.

Decreases in milk production ranged from 7.8 to 21.5 percent in five groups of cows shifted abruptly from corn silage and hay to legume-grass silage. Legume-grass silage was used to the best advantage when feeding was initiated 2 to 4 weeks before calving and continued through early lactation.

In experiments where dry matter digestibility was suppressed by sudden changes in the type of silage fed, daily silage intake was reduced and required a 2 to 4-week period to reach a new maximum. Apparent protein digestibility and **in vitro** protein synthesis by rumen contents were affected for a shorter length of time after change-over.

Feeding corn-preserved legume-grass silage following corn silage enhanced digestibility, feed intake and milk production. In a reverse experiment, feeding corn-preserved legume-grass silage following wilted legume-grass silage suppressed digestibility and feed intake and decreased milk production. Feeding alfalfa hay following legume-grass silage resulted in immediate increases in feed intake and milk production.

Using a ration designed to eliminate the possible effects of abruptly changing the ration on the rumen microflora and protein synthesis, it was shown that changing abruptly from corn silage and hay to a legume-grass silage and hay decreased milk production significantly while dry matter digestibility, feed intake and nitrogen retention increased. Total nitrogen efficiency and calculated net energy intake remained about equal for the two feeding periods. This experiment indicates that legume-grass silage may contain substances, which suppress milk production independently from rumen microflora and digestion effects.

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